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Received: 22 April 1998

Accepted: 10 June 1998

ADULT AND JUVENILE ANADROMOUS SALMONID MIGRATION TIMING IN CALIFORNIA STREAMS

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When oil spills occur in the vicinity of coastal stream mouths, chemical dispersants cannot be used if smolt or adult stages of salmonids are present. To aid planners in preparing for oil spills, monthly arrival times of spawning runs of adult anadromous salmonids and months when smolts outmigrate to the ocean at tidal inlets of California streams were compiled (Appendix 1). Only streams that empty directly into the ocean or Humboldt, San Francisco, or San Pablo bays are presented. The data were compiled from various publications and from interviews conducted with field biologists having personal knowledge of individual streams. Historical observations were included in cases where recent surveys have not been done or were inconclusive about the presence of salmonids. These data can also be used by resource managers who are reviewing projects that may affect water flow in the lower parts of coastal streams, or near tidal inlets, when migrating salmonids, adults or smolts, may be present.

Chinook salmon, *Oncorhynchus tshawytscha*; coho salmon, *O. kisutch*; and steelhead, *O. mykiss*, are the most abundant anadromous salmonids in California. The coastal cutthroat trout, *O. clarki clarki*, is also anadromous and found in small coastal streams from the Eel River in Humboldt County north to Alaska (Emmett et al.¹ 1991). Information on its migrations was not detailed enough for inclusion in Appendix 1. Pink salmon, *Oncorhynchus gorbuscha*; chum salmon, *Oncorhynchus keta*; and sockeye salmon, *Oncorhynchus nerka*, do not normally spawn in California and are not included.

Chinook salmon have 4 distinct runs in California. Runs are named after the season when they migrate from the ocean to fresh water for spawning: fall, late-fall, winter, and spring. The Sacramento River is used by all runs and is the only one to have late-fall and winter runs. Some other rivers also have more than 1 run. Most small coastal rivers have only a fall run.

Coho salmon have only 1 run and are most common in small coastal streams. They are not found in the Sacramento or San Joaquin River systems, but are found in small numbers in other tributaries to San Francisco Bay.

¹Emmett, R.L., S.A. Hinton, S.L. Stone, and M.E. Monaco. 1991. Distribution and abundance of fishes and invertebrates in West Coast estuaries, volume II: Species life history summaries. ELMR Report No. 8, NOAA/NOS Strategic Environmental Assessments Division, Rockville, Maryland, USA.

Steelhead spawning migrations are complicated by the fact that adult steelhead may be entering rivers to spawn or, unlike salmon, returning to the ocean following spawning. As a result, steelhead may be migrating year-round in larger rivers. Most California streams have only a winter steelhead run that migrates for spawning during fall, winter, and early spring. In addition to the winter run, the Klamath, Eel, and Mad rivers also have summer runs migrating for spawning during spring, summer, and early fall (Busby et al.² 1996). Unlike most rivers, the largest run in the Klamath River is the fall run.

Detailed information about outmigrating smolts is incomplete for most small coastal rivers and in many cases shows only the time when smolts entered the estuary, not the time when they actually migrated into the ocean. Residence time in an estuary is a function of species, run, and stream conditions. Generally, stream residence times are <1 year for chinook salmon, ≤1.5 years for coho salmon, and 1–6 years for steelhead. Unlike migrating adult salmonids that are often the target of anglers, smolts are usually small and difficult to see and attract no special attention. Generally, outmigration patterns are the same as for the geographically nearest stream of a similar size for which information is shown.

For most species of salmonids, the peak spawning migration is in fall and winter. Most chinook salmon smolts outmigrate in spring and summer. Coho salmon smolts outmigrate from March to July and usually peak between mid-April and mid-May.

Some runs of salmonids are listed as threatened or endangered. Sacramento River winter-run chinook salmon are listed by both the State of California and the Federal government as endangered (California Code of Regulations, Title 14; Federal Register, 50 CFR 17.11). Coho salmon in central California are listed by California as endangered and by the Federal government as threatened. Coho salmon in southern Oregon and northern California are listed by the Federal government as threatened. Coastal cutthroat trout and summer-run steelhead are species of special concern (Moyle et al.³ 1989). For a detailed listing of the status of coho for West Coast states and selected rivers, see Weitkamp et al.⁴ (1995). See Busby et al.² 1996 for a complete listing for steelhead.

Probably the most important environmental factors affecting the timing for both returning adult salmon migration and smolt outmigration, especially for small coastal streams, is the condition of the river mouth and the amount of runoff from rainfall.

² Busby, P.J., T.C. Wainwright, G.J. Bryant, L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of West Coast steelhead from Washington, Oregon, Idaho, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-27.

³ Moyle, P.B., J.E. Williams, and E.D. Wikramanayake. 1989. Fish species of special concern of California. Contract Number 7337, California Department of Fish and Game, Inland Fisheries Division, Sacramento, California, USA.

⁴ Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Department Commerce, NOAA Technical Memorandum NMFS-NWFSC-24.

Many small coastal streams are closed entirely by sand bars that build across their mouths during periods of low rainfall and mild ocean conditions in summer. Barnhart and Young⁵ (1986) describe conditions for the Mattole River that are typical of conditions for many small coastal streams and stress the importance of estuaries to salmonids. The first major upstream migrations coincide with large increases in stream flow, especially in streams with low summer flows (Shapovalov and Taft 1954). Heavy rainfall and subsequent runoff removes the bar and provides a pathway for migrating fish. Freshwater runoff may provide olfactory clues to attract migrating adult salmon into the stream. Heavy runoff also serves to 'flush' smolts trapped in an estuary into the ocean.

The largest populations of salmon are found in the Klamath and Central Valley river systems. Migrating adult spawners can exceed 100,000 fish in the Klamath River and 150,000 in Central Valley rivers (PFMC⁶ 1995). The Smith and Eel rivers also support large numbers of salmon, but in many of the streams in Appendix I, the number of spawning adults is low, perhaps fewer than 100 fish.

ACKNOWLEDGMENTS

We especially recognize G. Bryant, National Marine Fisheries Service, Southwest Region, Endangered Species Branch for providing resources and information on salmonid runs coastwide and for taking time from his schedule to edit and make comments on an earlier draft. We thank the following California Department of Fish and Game biologists who shared their knowledge: M. Cardena, W. Cox, W. Jones, W. Jong, P. Kalvass, D. McLeod, J. Nelson, L. Preston, L. Quirollo, M. Wallace, and C. Harvey. We also thank D. Anderson, U.S. National Park Service, for information about streams in Redwood National Park and T. Kisanuki, U.S. Fish and Wildlife Service, for information about the Klamath River estuary studies.

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Received: 10 March 1997

Accepted: 6 July 1998

⁵ Barnhart, R. and D. Young. 1986. Mattole Estuary habitat management plan. Sikes Act Project Number CA-056-WHA-A4. Available in the Humboldt Room, Humboldt State University Library, Arcata, California, USA. Call letters: SH222C3B371985.

⁶ PFMC (Pacific Fishery Management Council). 1995. Review of 1994 Ocean Salmon Fisheries. Portland, Oregon, USA.

Appendix 1. (continued)		Month											
Stream	Sp.	A	S	O	N	D	J	F	M	A	M	J	J
Abalobadiah C.	SH					A _w							
Ten Mile R.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
	CH		A _F	A _F	A _F			S	S	S	S	S	S
Mill C.	SH					A _w							
Virgin C.	SH					A _w							
Pudding C.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Noyo R.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
	CH		A _F	A _F	A _F			S	S	S	S	S	S
Hare C.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Digger C.	SH					A _w							
Mitchell C.	SH					A _w							
Jughandle C.	SH					A _w							
Caspar C. ^b	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Doyle C. ^b	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Russian G.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Big R.	CO		A	A	A	A	A	S	S	S	S	S	S

Appendix 1. (continued)		Month											
Stream	Sp.	A	S	O	N	D	J	F	M	A	M	J	J
Big R.	SH					A _w							
	CH					A _F	A _F	A _F			S	S	S
Little R.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Dark G.	SH					A _w							
Albion R.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
Big Salmon C.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
	CH		A _F	A _F	A _F			S	S	S	S	S	S
Little Salmon C.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
	CH		A _F	A _F	A _F			S	S	S	S	S	S
Navarro R.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							
	CH		A _F	A _F	A _F			S	S	S	S	S	S
Greenwood C.	SH					A _w							
Elk C.	SH					A _w							
Mallo Pass C.	SH					A _w							
Irish G.	SH					A _w							
Alder C.	SH					A _w							
Brush C.	SH					A _w							
Garcia R.	CO		A	A	A	A	A	S	S	S	S	S	S
	SH					A _w							

Appendix 1. (continued)

Stream	Sp.	Month												
		A	S	O	N	D	J	F	M	A	M	J	J	
Arena C.	SH					A _w								
Schooner G.	SH					A _w								
Fish Rock G.	SH					A _w								
Gualala R.	CO			A	A	A [*]	A [*]	A		S	S [*]	S [*]		
	SH				A _w									
Fort Ross C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Miller C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Stockhoff C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Russian G.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Russian R.	CO			A	A [*]	A [*]	A			S	S	S [*]	S [*]	S
	SH			A _w										
	CH	A _F		S	S	S	S [*]	S [*]	S					
Scotty C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Salmon C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Estero Americano	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Estero de San Antonio	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									

Appendix 1. (continued)

Stream	Sp.	Month												
		A	S	O	N	D	J	F	M	A	M	J	J	
Walker C.	CO					A	A	A [*]	A [*]	A				
	SH					A _w								
Lagunitas C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Glenbrook C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Muddy Hollow C.	CO			A	A	A [*]	A [*]	A		S	S	S [*]	S [*]	S
	SH				A _w									
Coast C.	CO			A	A [*]	A [*]	A			S	S	S [*]	S [*]	S
	SH				A _w									
Pine Gulch C.	CO			A	A [*]	A [*]	A			S	S	S [*]	S [*]	S
	SH				A _w									
Redwood C. (Pt Bolinas)	CO			A	A [*]	A [*]	A			S	S	S [*]	S [*]	S
	SH				A _w									
Redwood C. (Pt Bonita)	CO			A	A	A [*]	A			S	S	S [*]	S [*]	S
	SH				A _w									
Sacramento R. ^c	SH				A _w									
	CH	A _{SU}	A _{SU}	A _{SU}				S	S	S	A _{SU}	A _{SU}	A _{SU}	A _{SU}
		A _F	A _F	A _F	A _F	A _F	A _F	A _F	A _F	A _F				
											A _{SP}	A _{SP}	A _{SP}	A _{SP}
Rodeo C. ^c	CO			S	S [*]									
	SH				A _w									
Sonoma C. ^c	CO			A	A	A [*]	A			S	S	S [*]	S [*]	S
	SH				A _w									

Appendix I. (continued)

Stream	Sp.	A	S	O	N	Month												
						D	J	F	M	A	M	J	J					
Petaluma R. ^c	CO				A	A	A											
	SH					A _w		S	S	S								
Novato C. ^c	CO				A	A	A											
	SH					A _w		S	S	S								
Miller C. ^c	CO				A	A	A											
	SH					A _w		S	S	S								
Gallinas C. ^c	CO				A	A	A											
	SH					A _w		S	S	S								
Arroyo Corte Madera del Presidio ^c	CO				A	A	A											
	SH					A _w		S	S	S								
San Pedro C.	SH					A _w		S	S	S								
Denniston C.	SH					A _w		S	S	S								
Frenchmans C.	SH					A _w		S	S	S								
Pilarcitos C.	SH					A _w		S	S	S								
Lobitos C.	SH					A _w		S	S	S								
Tunitas C.	CO				A	A	A											
	SH					A _w		S	S	S								
San Gregorio C.	CO				A	A	A											
	SH					A _w		S	S	S								
Pomponio C.	CH					A _w		S	S	S								
Pescadero C.	CO				A	A	A											
	SH					A _w		S	S	S								
Gazos C.	CO				A	A	A											
	SH					A _w		S	S	S								

Appendix I. (continued)

Stream	Sp.	A	S	O	N	Month												
						D	J	F	M	A	M	J	J					
Whitehouse C.	SH					A _w		S	S	S								
Ano Nuevo C.	SH					A _w		S	S	S								
Waddell C.	CO				A	A	A											
	SH					A _w		S	S	S				S				
Scott C.	CO				A	A	A											
	SH					A _w		S	S	S				S				
San Vicente C.	CO				A	A	A											
	SH					A _w		S	S	S				S				
Liddell C.	SH					A _w		S	S	S				S				
Yellow Bank C.	SH					A _w		S	S	S				S				
Wilder C.	SH					A _w		S	S	S				S				
San Lorenzo R.	CO				A	A	A											
	SH					A _w		S	S	S				S				
Arana Gulch C.	SH					A _w		S	S	S				S				
Soquel C.	CO				A	A	A											
	SH					A _w		S	S	S				S				
Aptos C.	CO				A	A	A											
	SH					A _w		S	S	S				S				
Pajaro R.	CO				A	A	A											
	SH					A _w		S	S	S				S				
Salinas R.	SH					A _w		S	S	S				S				
Carmel R.	SH					A _w		S	S	S				S				
San Jose C.	SH					A _w		S	S	S				S				
Gibson C.	SH					A _w		S	S	S				S				

Appendix 1. (continued)		Month											
Stream	Sp.	A	S	O	N	D	J	F	M	A	M	J	J
Malpaso C.	SH					A _w	S [*]	S					
Garrapata C.	SH					A _w	S [*]	S					
Rocky C.	SH					A _w	S [*]	S					
Bixby C.	SH					A _w	S [*]	S					
Little Sur R.	SH					A _w	S [*]	S					
Big Sur R.	SH					A _w	S [*]	S					
Partington C.	SH					A _w	S [*]	S					
Lime C.	SH					A _w	S [*]	S					
Big C.	SH					A _w	S [*]	S					
LimeKiln C	CH					A _w	S [*]	S					
Mill C.	SH					A _w	S [*]	S					
Prewitt C.	SH					A _w	S [*]	S					
Plaskett C	SH					A _w	S [*]	S					
Willow C.	SH					A _w	S [*]	S					
Salmon C.	SH					A _w	S [*]	S					
San Carpofofo C.	SH					A _w	S [*]	S					
Arroyo de la Cruz	SH					A _w	S [*]	S					
Little Pico C.	SH					A _w	S [*]	S					
Pico C.	SH					A _w	S [*]	S					
San Simeon C.	SH					A _w	S [*]	S					
Santa Rosa C.	SH					A _w	S [*]	S					
Villa C.	SH					A _w	S [*]	S					
Toro C.	SH					A _w	S [*]	S					

Appendix 1. (continued)		Month											
Stream	Sp.	A	S	O	N	D	J	F	M	A	M	J	J
Morro C.	SH					A _w	S [*]	S					
Chorro C.	SH					A _w	S [*]	S					
Los Osos C.	SH					A _w	S [*]	S					
Islay C.	SH					A _w	S [*]	S					
Coon C.	SH					A _w	S [*]	S					
San Luis Obispo C.	SH					A _w	S [*]	S					
Pismo C.	SH					A _w	S [*]	S					
Arroyo Grande C.	SH					A _w	S [*]	S					
Santa Ynez R. ^d	SH					A _w							
Ventura R.	SH		A _w	A _w		A _w							
Santa Clara R.	SH					A _w							
Arroyo Siquet	SH					A _w							
Malibu C.	SH					A _w							
San Mateo C.	SH					A _w							
Santa Margarita C. ^e	SH							A _w					

^a These streams flow into Humboldt Bay, which opens to the ocean through permanently maintained jetties. Smolts use the bay as an estuary before entering the ocean.

^b Young-of-the-year coho salmon and steelhead, 25–35 mm total length, have been observed in the nearshore environment. Downstream migrant trapping data in Caspar and Doyle creeks indicate these fish form small schools and move from 1 stream to another to rear. Stream habitat typing indicates that the fish move from the stream with poor rearing habitat to the one with a better rearing environment.

^c These streams flow into San Francisco Bay (including San Pablo Bay). Information on smolt migration timing is based on the time they leave the stream or river, rather than the time they leave the bay for the ocean.

^d The Pacific slope of the Santa Ynez Mountains from Gaviota to Rincon has numerous small streams, many of which have runs of steelhead.

^e Steelhead have been observed in both San Mateo Creek and Santa Margarita Creek (Greg Bryant, National Marine Fisheries Service, personal communication).